Specifying for Industrial Insulation Systems

Gary Whittaker, Whittaker Materials Engineering Associates, LLC/National Insulation Association

We have all heard the old saying, "No job is complete until the paperwork is finished." When it comes to insulation, this saying should be changed to, "No job should be started until the paperwork is completed." Specifically, no insulation job should be started until an appropriate specification has been prepared and agreed to by all involved.

For most of us, the thought of sitting down to read an insulation specification does not exactly compare with the excitement of cracking open the latest page turner from Tom Clancy or John Grisham, but a well-prepared and well-written specification is critical to the success of any project. In the National Insulation Association's National Insulation Training Program (NITP) we spend considerable time talking about specifications and the design process that supports the creation of an effective specification. We use the Process Industry Practices (PIP) (1) as the basis for industrial specifications and the published Architectural Computer Services, Inc. (ARCOM) MASTERSPEC® (2) as the basis for commercial specifications. For this discussion we will focus on the industrial side and will use the PIP Practices as the basis for showing how to create or interpret an effective specification so you can have your paperwork completed before the job starts. Please note that although PIP will be referenced throughout this article, it is certainly not the only effective method for effective insulation specification.

What is a Specification?

What is a specification? According to the *American Heritage Dictionary*, it is a "detailed exact statement of particulars." True enough, but in the case of insulation it is far more than just a statement of particulars; it is how the designer communicates his intent to everyone involved, from the project manager to the installation contractor and the material suppliers. A good specification includes all the information the contractor needs to understand—what is to be insulated, the materials to be used, how they should be installed, and how they will be inspected. There is no such thing as a verbal specification. When an owner calls his local contractor and says, "Hi Bob, I have about 5,000 feet of pipe with a few valves and fittings that need to be insulated. I'd like you to come by tomorrow and take care of it. Just do the usual," he may have issued a verbal purchase order, but he certainly has not issued a specification, and he has left the door open to disaster. The contractor could interpret this to mean practically anything. An unscrupulous contractor might take advantage of the situation by using the latest in solid gold jacket, but the more likely scenario is that the owner will not get a system that is adequate for his application. The problems could be anything from an inappropriate insulation material to improper thickness.

In the case of inadequate thickness, the owner would end up wasting energy and could even have a safety problem if the jacket temperature turned out to be above the personnel protection temperature. The use of improper insulation material could result in energy loss, damage to the insulation, corrosion of the equipment, or even fire if a leaking chemical comes in contact with an incompatible insulation material. The lesson here is: don't just dust off an old specification and send it out. Each job should have a specification based on the specific project details.

By now you may be thinking, "Great, this guy thinks I need a 50-page specification to insulate 10 feet of pipe—typical engineer." A good specification does not have to be long to communicate the designer's intent in a clear and logical way. The authors of the PIP Practices had this in mind when they set out to create them. The end result is a series of text documents and datasheets that can be tailored to the needs of a specific project. A small project, such as 10 feet of pipe, might have just a few datasheets, while a large project could have many more. PIP was founded on the idea that standard specification formats used by everyone in the process industry would simplify the work of writing and reading specifications, and ultimately lower project costs.

In the case of insulation, the authors created a series of documents that cover engineering, materials specification, extent of insulation, detail drawings, and inspection.

Supporting these basic documents is a series of datasheets that are completed by the designer and read by contractors and material suppliers. The datasheets contain project specific information. The number of datasheets needed for a project depends on its size and complexity. At first glance, the PIP Practices are a daunting stack of paper, but with familiarity comes the realization that most of the PIP text is supporting information that does not change from project to project. After the text documents are learned, using the PIP Practices is an exercise in completing or reading datasheets.

Design

The first step in any insulation project is design. This is the process of identifying the important parameters that must be addressed through the materials selection process. Much of the NITP is focused on understanding the design process and how it is influenced by both the physical properties of the insulation materials and the unique characteristics of the system being insulated.

Using the PIP Practices helps the specifier through the design process by requiring him to make choices. The first PIP document he must consult is INEG1000, "Insulation Design and Type Codes." This practice contains the type code definitions used by PIP, and the designer must choose the code that applies to his project. The codes describe the basic purpose of the insulation and include heat conservation (HC), process stability (PS), personnel protection (PP), prevention from freezing (PF), cold conservation (CC) and condensation prevention (CP). By choosing a type code, the designer selects the fundamental design for his project. Later in the process this choice will be used to help determine what PIP calls the "extent of insulation," which is nothing more than what will be insulated and what will not be insulated. The code will also become a part of the project documentation because it is included in the line code for each item shown on the project's piping and instrument diagrams.

The type codes help establish the basic reason for insulating, but there are many more criteria the designer must consider before choosing materials. We begin each NITP class by asking the students what they hope to learn. Perhaps the most common answer is, "I want to learn more about the different insulation materials and how they are used." In other words, how do designers choose from all those materials? One of the key points in design is to understand that there are many ways to solve a problem, all of which will work to some degree.

With training and experience, the designer learns to choose the best solution from among the many workable solutions. He does this by looking at each of the design criteria that apply to his project, prioritizing them and then choosing materials that best meet his priorities. Designers are human, so this process has a degree of subjectivity. Not all end users or designers will agree on what design criteria should apply to a project, how they should be prioritized, or which materials will best meet their needs. Occasionally, factors outside the design process intervene to force the designer to change his approach. For example, the project could be a rush job for which the optimum material is not available and cannot be obtained in time to meet the schedule.

So, what are some of these other design criteria and how do we sort them out? The way to start is to ask, "What will be insulated?" Is the item a vessel, a piping system, or machinery? The nature of the insulated item will sometimes dictate what material is best suited for the application. For example, suppose we are insulating a large machine that is complex in shape and our primary criteria is condensation control. Would it be better to use a rigid material that would have to be cut many times to conform to the complex shape, or would it make more sense to use a flexible material that could be easily fit to the curves? How this question is answered dictates which material is chosen, and not everyone gives the same answer.

After understanding what will be insulated, we need to know what the operating temperature will be. This is probably the most fundamental question of all because it establishes the appropriate type code and narrows the field of appropriate material choices. If the process is operating at 752˚F, all the organic materials automatically drop out of consideration. Likewise, if the temperature is minus 122˚F the field might be narrowed to closed cell materials.

The next question is, "What is the nature of the process?" By this we mean, what chemicals are being handled, and do they have any unique properties that might influence the design?

Often this relates to the flammability or reactivity of the process chemicals. Some industrial facilities that process flammable chemicals use only closed-cell insulation materials to prevent leaking chemicals from saturating a more absorbent material and causing a fire.

I once worked with a plant that originally insulated a highly flammable process using fibrous material because it was their standard material for the temperatures involved. This chemical had a habit of destroying gaskets and valve seals and the standard method of finding leaks was to look for fires. The chemical was absorbed by the fibrous insulation until enough was present to cause auto-ignition. We solved the problem by changing to a closed-cell product and providing drainage to prevent a dangerous build up of the chemical. We also worked to find compatible gasket and seal materials. However, the bottom line is that leaks happen and if the consequences of a leak could be severe, then the insulation design should help to minimize those consequences.

It is important to know the material of construction of the insulated substrate. Much has been written about corrosion under insulation (CUI), and there is a recommended practice (RPO-198) published by the National Association of Corrosion Engineers (NACE) (3) intended to reduce the likelihood of corrosion through the use of coatings.

Not all end users follow the NACE recommendations, because in some cases, the risk of CUI is judged to be acceptable. In these circumstances, the choice of insulation material should be made to minimize the corrosion risk. For example, if a stainless steel line operating at 203˚F (a prime temperature for chloride stress corrosion cracking) is to be insulated and not coated, a non-absorbent material might be chosen in order to prevent the occurrence of conditions that could lead to corrosion. Some chemical companies take the “belt and suspenders” approach and use absorption-resistant materials along with following the NACE guidelines. All of this is dictated by the stainless steel substrate. This is just one example; other substrate materials present different problems that must be addressed by the designer.

The environment in which the insulation will operate influences many design choices. It is important to distinguish between indoor and outdoor conditions. If the insulation system is to operate fully exposed to the elements, then the choice of jacket material and how it is secured may be very different than if the system is inside a building. Outdoor systems generally require more robust jacket and sealing materials than indoor systems. Insulation is also exposed to people and it is this exposure that probably presents the greatest likelihood of damage. It is a fact of life in all chemical plants that insulated pipes and vessel tops make great ladders and platforms. Physical abuse can be addressed by choosing damage resistant materials. A solution many in the chemical industry use is to select a dense insulation material, such as calcium silicate or perlite, for the top surfaces of pipes and vessels that are likely to be damaged.

Material selection is clearly a major part of the specification process. An equally important part of the design process is deciding exactly what parts of the piping and equipment will be insulated. PIP refers to this as the extent of insulation and defines it as, “those items or systems that are to be insulated under requirements of a given type code.” Notice that the extent of insulation is directly related to the type codes that were chosen. The extent of insulation for heat conservation would be different than for personnel protection or cold conservation. PIP includes recommended extent of insulation datasheets for hot and cold service: INSH2001[1] and INSC2001. In a matrix format, the datasheets list many equipment items and with a simple “yes” or “no” they determine whether insulation should be applied to meet the desired criteria. Each datasheet also has blank columns and rows to allow the designer to tailor the extent of insulation to his specific project.

The final step in design, after choosing the materials and determining the extent of insulation, is calculating the appropriate thickness. Thickness should be based on the specific details of the project and the primary design criteria. For example, in many cases the thickness required for personnel protection will be different than that required for optimum heat conservation.

[1] Please refer to the Editor’s Note on page 37 for explanation of the PIP datasheet identification system mentioned in this article.

PIP

Requirements for Hot Service Insulation System

Data Sheet for Hot Service Insulation System for Project Specific Requirements

PIP INSH1001
PAGE 1 OF 1
JAN 97

PROJECT ____________ PAGE NO. _____ OF _____

DATE ____________

SERVICE OR ITEM DESCRIPTION	"TYPE" CODE	OPERATING TEMP. °F	MATERIAL	THICKNESS TABLE	SPECIAL REQUIREMENTS

NOTES:

Figure 1. Datasheet for hot service insulation.

PIP

Requirements for Hot Service Insulation System

Data Sheet - Calcium Silicate Insulation System for Pipe and Equipment

PIP INSH1002
PAGE 1 OF 1
JAN 97

Project: Date:

Service: Thickness Table: Temp Range:

Insulation Specification: Calcium Silicate performed pipe sections, curved segments and flat block shall conform to *ASTM C533*, Type 1. Beveled lags shall be used in the size range where curved segments are not commercially available. The material shall be continuously identified throughout to indicate that the product does not contain asbestos.

Approved Manufacturers

Manufacturer	Brand Name	Manufacturer	Brand Name

Accessories

Accessory	Description	Manufacturer	Trade Name

Figure 2. Datasheet for calcium silicate.

The North American Insulation Manufacturers Association (NAIMA) has published the 3E Plus® software program to calculate insulation thickness. 3E Plus is accepted as the standard method for determining insulation thickness. The 3E Plus user must provide project specific information on the process and the materials selected to determine the proper thickness. If economic thickness is determined to be considerable, project specific economic data must be supplied and it is unlikely that using data from past projects will produce an accurate answer.

Documentation

At this point, the designer has established design criteria, determined the extent of insulation, and calculated the required thickness. The next step in the process is to write it down. PIP provides a series of datasheets that are used to communicate the decisions made in the design process. The first are tables used to describe the system design, INSH1001 for hot and INSC1001 for cold. Each row in the first column is used to record an item or system to be insulated, for example, "10 feet of pipe." Next are columns to record the type code, operating temperature, insulation material, thickness table and finally a column to record special requirements.

The designer could sit down with an equipment list or piping line list and record the insulation material, type code, thickness table, and any special requirements for the entire project in one table. It could be for 10 feet of pipe or 10 pressure vessels. Figure 1 is an example INSH1001.

The next datasheets provide detailed information on the selected materials and the accessories that have been chosen to install that material. There is a material datasheet for each major material covered by PIP. Figure 2 is the PIP provided sample for calcium silicate. There are spaces to identify the project and list the approved manufacturers for all the accessory items. INIH1000 and INIC1000 are a collection of detailed installation drawings that describe the PIP preferred installation methods. The specifier selects only the drawings that apply to his project for inclusion in the package.

Finally, there are datasheets, INSH2002 and INSC2002, that are used to list all of the documents to be included in the package—the datasheet datasheets. It may seem strange to have a datasheet for datasheets, but in a big project that might include many datasheets, it is helpful to have them all recorded in a single location. Each of the datasheets has a text document that provides supporting information and should be supplied with the datasheets, at least until the contractor has learned the system. For example, INSH2000, "Installation of Hot Service Insulation Systems," provides text information that expands and supplements the installation information shown on the detail drawings.

At this stage the process is almost complete. The designer has established and prioritized the design criteria, selected materials, calculated thickness, determined the extent of insulation, and completed the datasheets necessary to communicate the information. All of this is assembled into a package for transmittal to the contractor and material suppliers. For a project that has just 10 feet of pipe, the package could be as small as two datasheets, a drawing, and the supporting text documents. If the contractor is familiar with PIP and already has the text documents and drawings, then all that is really needed are the two datasheets. If it is a big project with many pipes and vessels, then the package will be larger.

Inspection

If you have followed the process, you now have a good specification. But does a good specification guarantee a good installation? In a perfect world it would, but unfortunately we do not work in a perfect world. Inspection is a key part of the insulation process; it is important to determine what inspections will be required and what results are acceptable. Without acceptance criteria the contractor does not know to what standard he will be held and the inspector does not know how or what to inspect. PIP has created an inspection standard, INTG1000, which provides an inspection checklist for use by both the inspector and the contractor. The inspection practice should be included in the specification package, which should be discussed in detail with the owner, contractor, and inspector before the job begins, preferably in a pre-job conference. There should be agreement between all parties about the specification requirements and about how discrepancies will be handled. There should never be arguments after the job has started about what the specification requires.

Finally, does the PIP Practices have to be used to write a good specification? Clearly the answer is no. PIP is an example of how an industrial specification package can be assembled. It contains all the critical elements needed to establish the basic design criteria, to choose the insulation materials, to determine thickness, and to communicate all the important information to everyone involved. Many companies, end users, and engineering contractors use unique specification documents to effectively carry out the same mission as PIP. While they use different formats, the good ones all communicate the same basic information.

In summary, any good specification communicates why we are insulating, what we are insulating, with what materials, and how they are to be installed.

References

1. Process Industry Practices, *www.pip.org*.
2. Architectural Computer Services, Inc., ARCOM MASTERSPEC®, a product and registered trademark of The American Institute of Architects, *www.aia.org*.
3. National Association of Corrosion Engineers, Standard Recommended Practice RPO198-2004, *The Control of Corrosion Under Thermal Insulation and Fireproofing Materials—A Systems Approach*, reaffirmed March 2004, *www.nace.org*.

Editor's Note: The PIP "Insulation Document Use Guideline," (INGG1000), 1997, defines the eight-character datasheet identification system as follows:

The first two characters designate the function team. For example:
IN - Insulation

The third character is the PIP section designator:
G - General
E - Engineering Design
I - Installation
S - Specification
Q - Quality Assurance

The fourth character designates service category:
A - Acoustical Insulation
C - Cold Insulation
D - Dual Temperature Insulation System
F - Fire Proofing Insulation
G - General
H - Hot Insulation

The last four characters designate numerical sequence of the datasheets.

Please see *www.pip.org* for more information.